DOCUMENT RESUME

ED 264 102 SE 046 262

TITLE Solar Cooking. What We Make. Science and Technology Education in Philippine Society.
INSTITUTION Philippines Univ., Quezon City. Inst. for Science and Mathematics Education Development.
SPONS AGENCY Educational Development Projects Implementing Task Force (Philippines).; National Science and Technology Authority (Philippines).
PUB DATE Aug 84
NOTE 25p.; For other documents in this series see SE 046 255-274.
AVAILABLE FROM University of the Philippines, Institute for Science and Mathematics Education Development, Pardo de Tavera St., Diliman, Quezon City, Philippines ($2.00).
PUB TYPE Guides - Classroom Use - Materials (For Learner) (051)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Alternative Energy Sources; Cooking Instruction; *Energy Education; Foreign Countries; High Schools; Learning Activities; Science Activities; Science Education; *Secondary School Science; *Solar Energy
IDENTIFIERS *Philippines; *Solar Cooking

ABSTRACT

This module is designed to help students: (1) describe a way of tapping solar energy; (2) identify the main parts of a box type solar cooker; (3) describe how each part contributes to the trapping of heat energy in the cooker; (4) cook some food in a solar cooker; and (5) recognize that food cooked in a solar cooker is safe to eat. It includes: an introductory comment about solar energy, pointing out that the Philippines is within the equatorial band of the earth which receives the highest concentration of solar radiation; information on cooking with solar energy; activities (which focus on the parts of a solar cooker and on cooking with the device); a self-check (with answers); and instructions for constructing a solar cooker. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

What We Make

SE 046 262

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Univ of the Philippines Inst. for Science and Math.

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Science and Technology Education in Philippine Society

Solar Cooking

This is one of a series of science modules prepared by the University of the Philippines Institute for Science and Mathematics Education Development (ISMED) supported by the Educational Development Projects Implementing Task Force (EDPITAF) and the National Science and Technology Authority (NSTA).

Section 9, P.D. 49: "No copy shall subsist in any work of the government of the Philippines. However, prior approval of the government agency or office wherein the work is created shall be necessary for exploitation of such work for profit. Such agency or office may, among other things, impose a condition the payment of royalties."

Published and printed by the

INSTITUTE FOR SCIENCE AND MATHEMATICS EDUCATION DEVELOPMENT
Vidal A. Tan Hall
University of the Philippines
Diliman, Quezon City
August, 1984

SOLAR COOKING

PROJECT TEAM

Writing Team	Magdalena C. Mojica (principal writer) Vivien M. Talisayon Celina N. Clemente
Consultants	Ernesto Terrado Bureau of Energy Development Staff Dominador Canlas Rey Munda
Reviewers	Porfirio P. Jesuitas Dolores F. Hernandez
Assisting Staff	Monica A. Montaña Teodulo V. Javier
Illustrator	Yolanda E. David
Compositors	Adelwisa D. Cachero Filipinas M. Mendoza
Layout Artist	Benedicto A. Artugue
Publications Staff	Arthur V. Abaloyan Ester A. Bautista Camilo M. Encarnacion Ruben L. Gabuat Regino L. Lamorena Pedro A. Laurino Renante M. Lunas Erlando B. Mangaser Guillerma F. Plata Cesar M. Sagun

ACKNOWLEDGMENT

The technical assistance of the Bureau of Energy Development, Ministry of Energy in the development of this lesson as well as of the solar cooker is gratefully acknowledged.

Solar Cooking

As early as the 1970's people began talking about the worldwide high cost of oil. Its supply is limited and the demand for it is high. Other energy resources like coal and natural gas are also rapidly being used up. One result is a continuous increase in the cost of such energy sources. Since energy is used at home, in industries and transportation, energy sources other than oil, coal and natural gas must be developed.

The development and use of alternate energy resources is an important national development goal of the Philippines today.

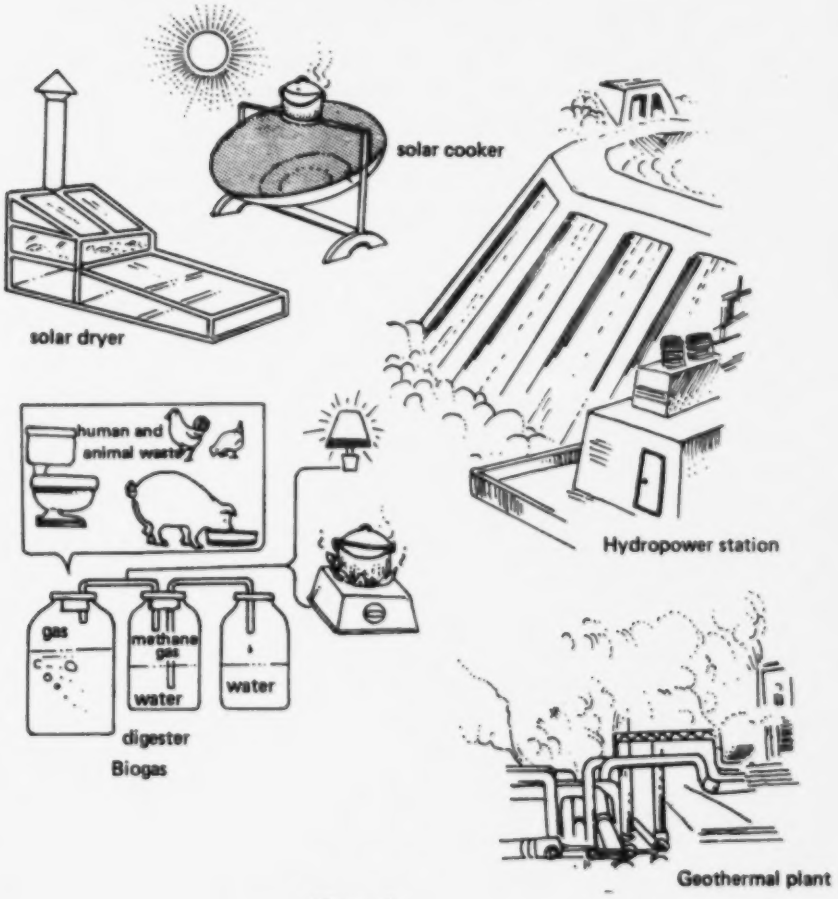


Figure 1

Solar energy is considered a promising resource. It is abundant, cost-free and a non-polluting resource. The Philippines is within the equatorial band of the earth which receives the highest concentration of solar radiation.

Solar Energy

Energy from the sun is transmitted as radiant energy. Upon striking a surface, part of the radiation is absorbed and transformed into an equivalent amount of heat energy. This heat is due to the motion of the atoms and molecules in the surface. Heat may be stored in the material or conducted to surrounding materials, warming them in turn.

Although the sun sends out great amounts of energy, not all the energy reaching the atmosphere of the earth gets to its surface. About 35% to 43% of the energy is reflected back into space by clouds, gases and dust in the atmosphere. So, only about half of the solar energy entering the atmosphere reaches the earth's surface.

The earth, at its average distance from the sun, receives around 8 joules of heat per square centimeter of its surface per minute. The Philippines gets a good share of sunlight averaging about 2000 hours a year. Table 1 lists the average daily solar radiation in some places in the country.

Table 1. **Solar Radiation Data***

Location	Average Daily Solar Radiation (x 10^6 joules per square meter)
Baguio City	17.2
Cagayan	17.6
Cavite	18.1
Cotabato	18.6
Laguna	17.9
Ilocos Norte	20.0
Leyte	17.5
Metro Manila	18.9
Negros Occidental	17.8
Northern Samar	19.2

*Source: Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)

The sun constitutes the earth's most abundant energy source. Many of the earth's sources of energy are obtained directly or indirectly from the sun's energy. For example, through the process of photosynthesis, the sun is the source of all food energy. Through deposits of living matter, coal and oil resources are formed. Through the convection currents that the sun sets up, wind power is produced.

Solar energy can be transformed also into electrical or mechanical energy through solar cells or solar pumps. These devices, however, are still too expensive for large scale practical applications.

Another application of solar energy is solar cooking. In solar cooking, the energy of the sun is used in the form of trapped heat.

This lesson focuses on a solar device, the solar cooker. In particular, at the end of this lesson, you should be able to:

1. describe a way of trapping solar energy;
2. identify the main parts of a box type solar cooker;
3. describe how each part contributes to the trapping of heat energy in the cooker;
4. cook some food in a solar cooker; and
5. recognize that food cooked in a solar cooker is safe to eat.

Answer questions marked ☐ in this module. Write the answer in your notebook and check your answers with the key at the end of this module.

As soon as you complete the entire lesson, answer the questions in your Check Yourself. Check your answers with the key that follows the test.

Solar Cooker

A fundamental activity of man is cooking. He has to cook most of the food he eats to make it more digestible and easy to assimilate, and to kill any harmful bacteria in the food.

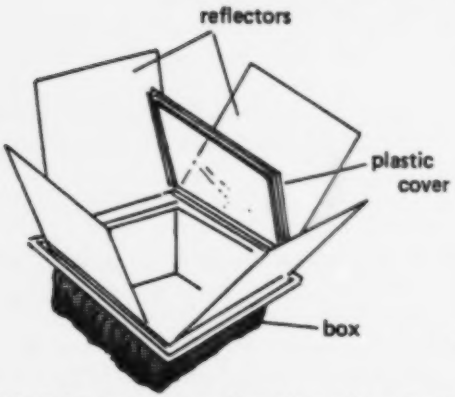
Different kinds of fuel are used for cooking.

☐ 1. What kinds of fuel are commonly used in cooking?

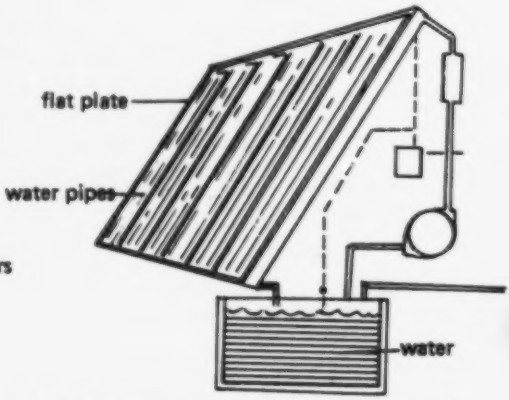
☐ 2. Which fuel do you use at home? Why do you use this kind of fuel?

What happens if fuel becomes very expensive or less available? This is the time perhaps when alternate sources of heat energy will have to be used. For instance, the energy of the sun can be used in cooking food, by means of a solar cooker.

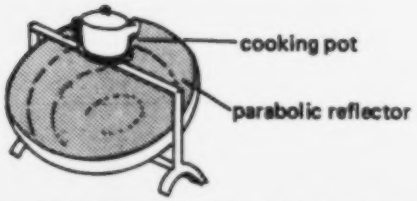
A solar cooker is simply a solar heat collector which transforms solar energy into heat energy. Three types of solar cookers are shown in figure 2.



(a) Solar oven – an enclosed box with reflectors to direct the sun's energy inside.



(b) Solar water heater – a high temperature flat plate collector.



(c) Parabolic solar cooker – a concentrating parabolic dish reflector that focuses a large amount of the sun's energy into a small area where cooking takes place.

Figure 2 Types of solar cookers

These devices can be made out of local materials which are low cost and safe to use. The parabolic heater should be used carefully. The focusing power of the parabolic mirror may cause burning or injury to the eye.

The solar oven or box type will be discussed, constructed, and tried in this lesson.

A basin of water under the sun gets warm after sometime. However, the temperature is not high enough to boil the water. It may just make the water warm but not hot enough to make it boil.

☐ 3. Under standard atmospheric pressure, at what temperature in °C (degrees Celsius) will make water boil?

If you can increase the temperature of the water to 80°C or higher using the energy from the sun, you can do solar cooking.

The device shown in figure 3 is a box-type solar cooker.

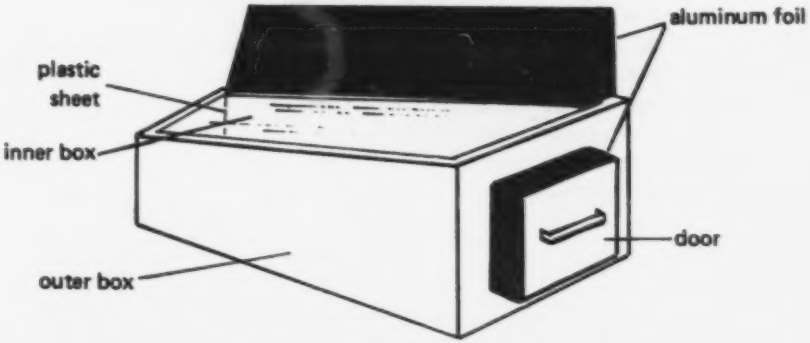


Figure 3 A box-type solar cooker

How can this device, when placed under the sun, have a temperature inside that is high enough to cook food?

Look at the labeled parts and think how each part can help in raising the temperature inside the cooker. The following activity will help you find out the use of each part.

Activity 1. Reaching a Higher Temperature

Do this activity if possible with 5 other students on a sunny day. You will need:

2 thermometers
5 boxes about 18 cm by 18 cm X 5 cm
2 boxes about 23 cm X 23 cm X 5 cm
4 plastic sheets about 20 cm X 20 cm
3 sheets carbon paper about 18 cm X 18 cm
masking tape
paste
old newspapers

1 plane mirror about 18 cm X 18 cm
1 pc. of wood about 1 cm X 1 cm X 38 cm
4 pcs. of wood about 1 cm X 1 cm X 45 cm
rubber bands

Preparing the boxes

Prepare the boxes like those shown in figure 4. Label these boxes – I, II, III, IV, and V. In setting up the boxes take note of the following:

1. Boxes II, III, IV and V are each covered with a plastic sheet taped to the sides of the box. A small hole should be cut near the corner of the plastic cover for the thermometer to be inserted.
2. Boxes III, IV and V are lined with carbon paper at the bottom.
3. Boxes IV and V each consists of two boxes. The larger box makes double walling with the inside box. Crumpled old newspapers are inserted in between the two boxes.
4. Box V is the same as box IV except that it has a mirror placed on a stand set up on top of the box.

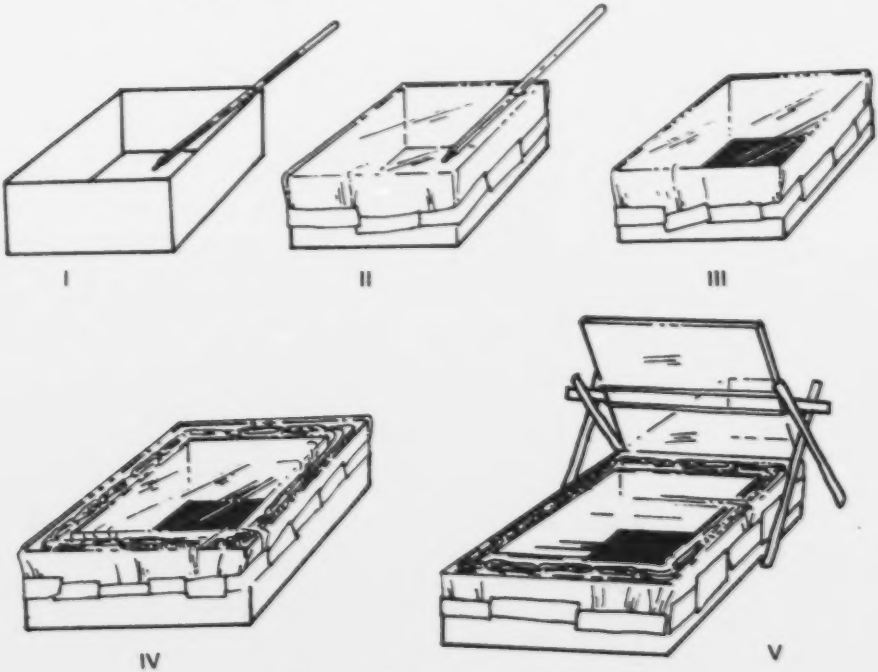


Figure 4 Set-up of boxes

Procedure:

A. Place boxes I and II on a sunny place. Immediately take the original temperature inside each box and record in table 1.
B. After 10 minutes take again the temperature inside each box. Record this as the final temperature in table 1.
C. Repeat procedures A and B for boxes III, IV and V.

If five thermometers are available, steps A and B can be done with the five boxes at the same time.

Table 2. **Temperature Inside Different Boxes**

Box	Box Condition	Thermometer readings		Temperature Difference, $t_f - t_i$ (°C)	Sky and surrounding conditions (clear, cloudy, windy or changing)
		Initial temp. t_i (°C)	Final temp. t_f (°C)		
I	Open box				
II	With plastic cover				
III	Same as II plus carbon paper				
IV	Same as III plus insulated walls (double walled)				
V	Same as IV plus mirror				

From your data, compare the temperature difference of the boxes.

☐ 4. Which has a higher temperature difference, $(t_f - t_i)$, box I or II?
☐ 5. What causes the higher temperature difference?

Notice that, in step A, the plastic cover affects the temperature of box II. You have also observed that sunlight passes through transparent materials like plastics.

Energy from the sun is transferred through a great distance and empty space. Sunlight also passes to the earth through transparent materials like glass and cellophane. Such a way of energy transfer is called *radiation*.

All bodies, hot or cold, keep on taking in and giving off energy. In box II, when sunlight passes through plastic, the high energy radiation of the sun is taken in by the molecules of air and other materials inside the box. This energy is then given off as heat or low energy radiation. However, low energy radiation cannot pass through plastics and other transparent materials. So heat, or low energy radiation is trapped inside the box.

☐ 6. Which has a higher temperature difference, $(t_f - t_i)$, box II or III?

☐ 7. What causes the higher temperature difference?

When sunlight strikes a white and shiny material, most of its energy bounces back or is reflected. Black and rough materials take in about 97% of the energy falling on it. The faster a body takes in high energy radiation, the faster it is given off as low energy radiation. Again, this low energy radiation is trapped inside the box because it is covered with plastic.

☐ 8. What color of dress or shirt should you wear when you do this activity under intense sunlight? (a) transparent (b) black or dark color (c) light color

☐ 9. Give a reason for your choice.

Another way of transferring heat energy is by **conduction.** Energy is transferred from one molecule to another. The more compact the molecules of the materials are, the faster is the conduction process. Generally, metals are good conductors of heat. Poor conductors are called insulators. Paper, sawdust, and air are good insulators.

☐ 10. Which has a higher temperature difference, $(t_f - t_i)$, Box III or Box IV?

☐ 11. What causes the higher temperature difference?

☐ 12. What is the use of the newspapers inserted between the boxes?

Good insulation prevents heat from escaping the box through the sides and bottom of the box.

☐ 13. Which one has a higher temperature difference $(t_f - t_i)$, box IV or V?

☐ 14. What causes this higher temperature difference?

In box V, the sun's rays passing through the plastic cover include reflected sunlight. You probably noticed that sunlight is reflected by the mirror into the box (Fig. 5). The inclination of the mirror determines the direction of reflected sunlight.

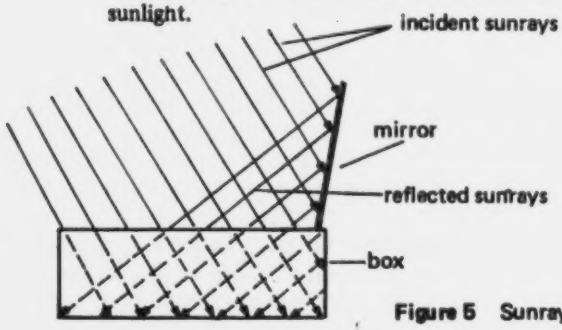


Figure 5 Sunrays reflected by mirror into the box

The angle at which sunlight strikes the surface is equal to the angle at which the light is reflected. Using a mirror to reflect sunlight into the box greatly increases the collected heat energy inside the box.

☐ 15. Which box has the highest temperature difference?

☐ 16. What are the reasons for this highest temperature?

☐17a. How will you find out if a glass cover results in a higher temperature than a plastic cover?

b. What conditions will you make constant? In what way will the boxes differ?

Box V has the important parts of a solar oven. Instructions for constructing the box-type solar cooker are given in the Appendix.

What food can be cooked in a solar cooker? Is it safe to eat food cooked under the sun? Find out in the next activity.

Activity 2. Cooking Under the Sun

Do this activity on a sunny day between 10:00 A.M. and 2:00 P.M. You and a partner need:

1 solar cooker (see Appendix for construction procedure)

2 thermometers

2 cans painted black (small-sized biscuit cans with cover) or 2 identical small pots

2-10 eggs, 2-10 pcs. medium sized camote, *or* 2-10 pieces ripe banana (saba)

clean water

A. Place the solar cooker on a sunny area.

B. Orient the cooker so that the lower portion is at the south while the higher portion is at the north (Fig. 6). See Appendix for explanation of this position. Adjust the flaps so that heat energy is reflected inside the can.

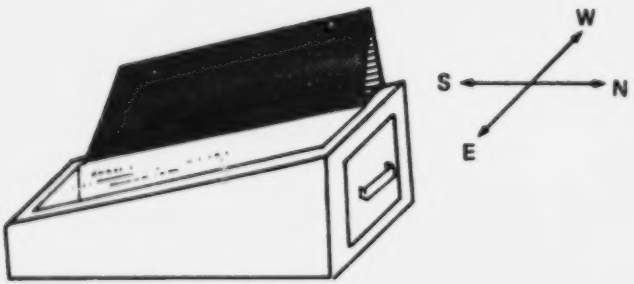


Figure 6 Orientation of the solar cooker

C. Fill each can with water about 4 cm deep.
D. Bore a 0.6 cm diameter hole on the cover of each can.
E. Insert a thermometer into the hole. Place the cover on the can such that the thermometer bulb touches the water.
F. Place one can inside the cooker and the other one outside.
G. Read the thermometer in one can at the same time that your partner reads the thermometer in the other can. Record your data in Table 2.
H. Repeat G every 30 minutes until the temperature inside cooker reaches 80°C.

Table 3. **Temperature of Water Inside and Outside Cooker**

Time	Temperature of water		Sky and surrounding conditions (cloudy, windy, clear, or changing)
	Inside cooker	Outside cooker	

I. When the temperature of water inside the cooker reaches 80°C, start cooking. Place the eggs, pieces of camote and/or banana in the can of water inside the cooker.
J. Every 30 minutes, repeat G and find out if the food is cooked. Continue solar cooking until the food is cooked. You and your partner should taste or eat the cooked food.

☐ 18. With the same time interval, how would you compare the increase in temperature of water inside with that outside the cooker?
☐ 19. Why are the cans painted black?
☐ 20. What is the fuel used by the solar cooker?
☐ 21. Which is more expensive to use, a stove or the solar cooker you used? Why?
☐ 22. Why is solar cooking recommended at 10:00 A.M. to 2:00 P.M. on a sunny day?
☐ 23. In which months of the year can you best use a solar cooker?

Some people say that food exposed to the sun gives stomach ailment. It is not always true. It depends upon the temperature at which food is exposed. A

type of harmful bacteria called **thermophiles** multiplies most at a temperature range of 45°C to 60°C. However, these bacteria do not thrive from 75°C to 150°C, the cooking temperature range. Food cooked within this temperature range, like what you have cooked is safe to eat.

Answers to Questions:

☐ 1. Wood, petroleum, cooking gas, electricity, charcoal
☐ 2. Any of those given in ☐1 may be mentioned for one or more reasons.
☐ 3. 100°C
☐ 4. Box II
☐ 5. Plastic sheet cover in box II. (The plastic sheet traps heat or low energy radiation inside the box.)
☐ 6. Box III
☐ 7. Box III is lined with black carbon sheet at the inside bottom. (A black material absorbs most of the energy falling on it.)
☐ 8. C
☐ 9. Less heat energy is absorbed by light colored clothing.
☐ 10. Box IV
☐ 11. Box IV has insulated walls. (The insulated walls lessen the heat transfer to the outside.)
☐ 12. Newspapers are good insulators, lessening heat transfer to the outside by conduction.
☐ 13. Box V
☐ 14. Mirror in box V. (The mirror reflects sunlight into the box.)
☐ 15. Box V
☐ 16. It has the following parts: (a) plastic sheet, (b) black carbon paper lining, (c) insulated walls, and (d) mirror. Parts (a) to (c) lessen heat losses to the outside. The mirror, by reflection allows more sunlight to go inside the box.
☐ 17a. One way is to have two identical boxes like box V except that one has a plastic cover and the other has a glass cover. Place both boxes in a sunny area. Take the temperature inside each box. After ten minutes, take again the temperature inside each box. Compare the final temperature of the boxes.
b. In all parts except the cover. The procedure must be identical. The temperature must be taken at the same time for the two boxes.
c. The cover, plastic for one box, and glass for the other.
☐ 18. Greater inside the cooker than outside.
☐ 19. To absorb more heat energy.
☐ 20. Solar energy

☐ 21. Stove, if you have to spend for fuel.
☐ 22. At this time, sunlight is most intense. (The sun is almost directly overhead and sun's rays are almost perpendicular to the top surface of the cooker.)
☐ 23. Summer months and other sunny months like August and October.

Check Yourself

1. Solar energy reaches the earth by

   A. conduction
   B. radiation
   C. absorption
   D. reflection

2. Which material can **best** reflect solar energy?

   A. aluminum foil
   B. carbon paper
   C. plane mirror
   D. plastic sheet

3. Which material is not good at transmitting high energy radiation and trapping heat energy?

   A. aluminum foil
   B. cellophane sheet
   C. glass plate
   D. plastic sheet

4. Mrs. Ferrer's house has windows and doors made of glass. One sunny day, the windows and doors were closed. Which of the following is true regarding the temperature inside Mrs. Ferrer's house?

   A. It was lower than the temperature outside.
   B. It was higher than the temperature outside.
   C. It was the same as the temperature outside.

5. Which of the following may be substituted for crumpled newspapers in a home-made solar cooker?

   A. crumpled plastic
   B. small pieces of wood
   C. small pieces of glass
   D. small pieces of metal

6. Which is **not** a factor affecting the use of solar energy?

   A. time of the day
   B. month of the year
   C. location of the cooker in relation to the house
   D. location of the cooker in relation to the equator

7. Which is true regarding food cooked in a solar cooker? The food

   A. has a foul odor.
   B. is spoiled.
   C. is more delicious than food cooked in ordinary stove.
   D. tastes the same as food cooked in ordinary stove.

Key: 1. B 3. A 5. B 7. D
2. C 4. B 6. C

Appendix

Construct Your Own Solar Cooker

You will construct your solar cooker part by part. The materials and procedure for each part are given.

I. Big Carton Box

Materials:

1 big carton box A about 42 cm X 64 cm X 42 cm
tape or paste
blade or pair of scissors
ruler
pencil

1. Close the bottom flaps and tape it.
2. Cut the box according to the dimensions in figure 7.

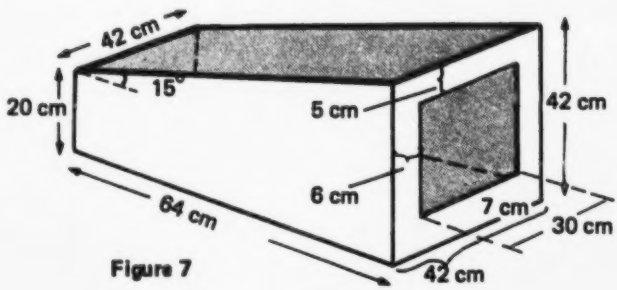


Figure 7

The energy absorbed by a surface on earth depends upon the angle at which the sun's rays hit the surface. The energy absorbed is greatest if the sun's rays are perpendicular to the surface. At the equator, the sun's rays are perpendicular to the surface of the earth.

The Philippines is a few degrees above the equator. Metro Manila for instance is 15° north of the equator. So, the sun's rays hit Metro Manila at an

angle of 15°. The solar energy absorbed in Metro Manila is less than that at the equator.

The solar cooker must be designed so that the sun's rays are perpendicular to the top plastic cover. If in Metro Manila, cut the solar cooker at an angle of 15° (Fig. 1). The latitude of a place is the angle at which the solar cooker is cut.

The cooker should also be oriented in the North-South direction so that at any time of the day, the incident rays are perpendicular to the top surface area of the cooker.

II. Small Carton Box

1 small carton box B about 58 cm X 30 cm X 32 cm (condense milk box is an example)
1 plastic sheet about 62 cm X 34 cm X 1 mm
7 carton sheets 30 cm N 6 cm
aluminum foil
blade or pair of scissor
tape or paste
ruler
pencil

1. Close and tape the bottom flaps.
2. Remove one side of the box.
3. Cut the box according to the dimensions in figure 8.

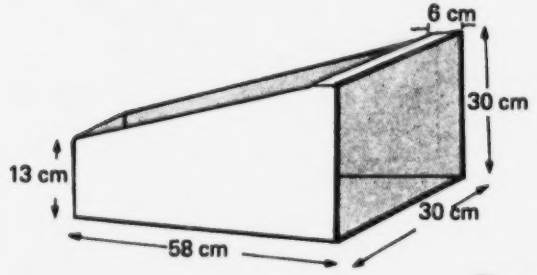


Figure 8

4. If needed, add carton sheet at one end to have the required length.
5. Place the 7 carton sheets on top of the other until about 2 cm thick. Tape the sides to hold them together.
6. Tape the thick carton sheet in (5) on top of the higher edge of the carton box as shown in figure 8.
7. Paste aluminum foil in every space inside and outside the box. Make sure there are no gaps at the edges of the foil where air can pass through. Let it dry.

8. Paste carbon paper at the flooring and inside walls of the box. Let it dry.
9. Cover the top with plastic sheet and tape it to the sides. See to it that the box is well sealed.

III. Door (Box C)

1 carton sheet (x) about 30 cm X 30 cm
1 carton sheet about 29.5 cm X 29.5 cm
2 carton sheets about 50 cm X 6 cm
aluminum foil
old newspapers
hammer
masking tape
2 pieces of wood about 2 cm X 3 cm X 12 cm
4 pieces of nails about 3 cm long

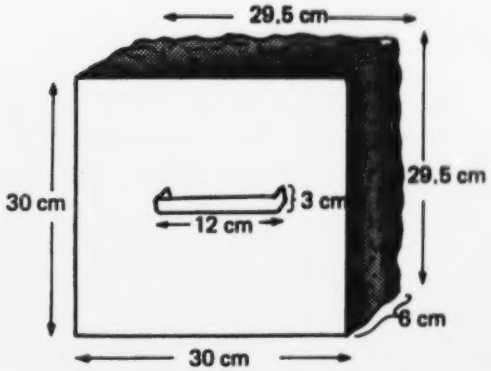


Figure 9

1. To construct the handle, insert the carton sheet (x) in between the two pieces of wood. Nail one piece of wood to the other through the carton sheet (Fig. 9).
2. Construct a box out of the remaining carton sheets. Paste aluminum foil lining inside the box.
3. Fill the box with crumpled newspapers.
4. Cover the box with carton sheet you have in (1).
5. Paste aluminum foil outside the box except the front side as in figure 9.

IV. Reflector

1 piece of wood, 58 cm X 6 cm X 1 cm
1 piece of cardboard, 58 cm X 36 cm
1 piece of cardboard, 58 cm X 28 cm
flat mirror or aluminum foil, 60 cm X 32 cm
paste or tape

1. Construct a triangular stand out of the pieces of cardboard using the dimension in figure 10.
2. Paste or tape the aluminum foil on one side of the triangular stand.
3. Insert the piece of wood at the base of the stand.

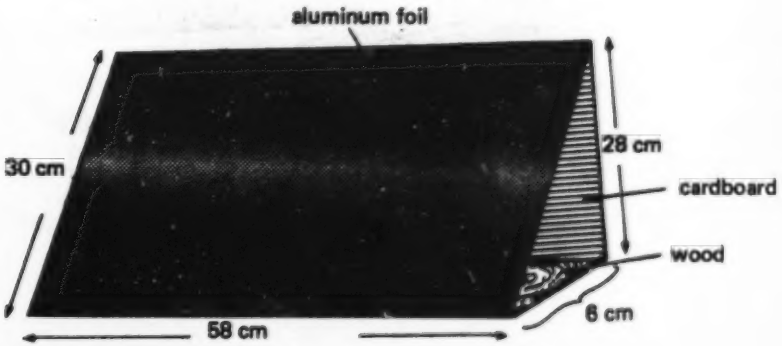


Figure 10

V. Assembly of Parts

You need:
4 long carton sheets about 64 cm X 6 cm
4 short carton sheets about 30 cm X 6 cm
1 plastic sheet (smaller) 70 cm X 45 cm
1 bigger plastic sheet 76 cm X 48 cm
old newspapers
masking tape
Box A
Box B
Door or Box C
Reflector

1. Fill box A with crumpled newspapers until 7 cm thick. Compress.
2. Place box B on top of the crumpled newspapers. See to it that the spaces between boxes are approximately equal.

3. Fill the spaces in between boxes with crumpled newspapers. Compress.
4. Cover the newspapers with 2 long carton sheets and 2 short carton sheets.
5. Compress so that it is approximately 1/2 cm from the top of box A. Tape it to the walls of box A.
6. Place the smaller plastic sheet on top of box B. Stretch the plastic and tape it to the sides.
7. Place the remaining carton sheets to frame the smaller plastic sheet. Tape it to the sides (Fig. 11).

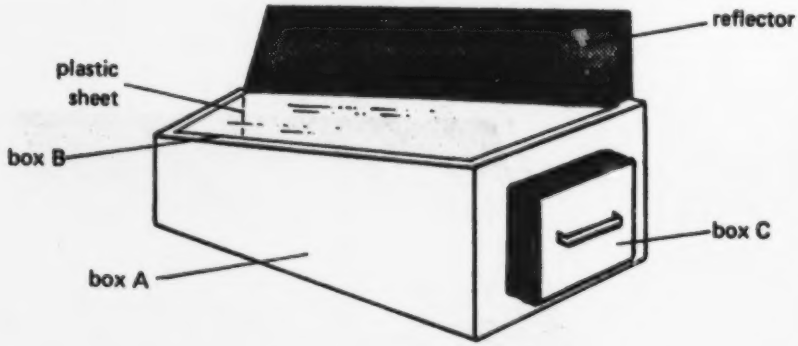


Figure 11

8. Cover the box with bigger plastic sheet and tape it to the outer side.
9. Attach the reflector to the box by taping it to the side. Attach the door to the cooker. See figure 11.

What you have just constructed is a solar cooker. This may not be the best design for a solar cooker. You can make your own design. Suggest substitute materials for different parts of the cooker.

References

1. Australian Science Education Center. *Solar Energy. Teacher Edition.* Melbourne: C.H. Rixon Government Printer, 1974. pp. 45-58.

2. Daniels, Farrington. *Direct Use of Sun's Energy.* New Haven and London: Yale University Press, 1964. pp. 90-122.

3. Edward, Donald Kenneth. *Solar Collector Design.* Philadelphia: Franklin Institute Press, 1977. pp. 9-19, 56-57.

4. Jenkins, IML. *The Working World of Physics.* London: Thomas Nelson and Sons Ltd., 1972. pp. 84-89.

5. Jenness, J.R. Recommendations and Suggested Techniques for the Manufacture of Inexpensive Solar Cookers. *Solar Energy*. 4, 1960. pp. 22-24.

6. Meinel Aden and Meinel, Marjorie. *Applied Solar Energy, An Introduction.* Massachusetts: Addison Wesley Publishing Co., 1977, pp. 230-234.

7. Pelczar, Michael Jr. and Reid, Roger. *Microbiology.* New York: McGrawhill Book Co., 1958. pp. 85-86.

8. Planck, Max Karl Ernst Ludwig. *The Theory of Heat Radiation.* New York: Dover Publications, 1959. pp. 1-21.

9. University of the Philippines Science Education Center. *Exploring Our Environment.* Quezon City. MECS-EDPITAF, 1977. pp. 190-203.